Ames Research Center

CAD INTERFACE, STRAND GRID TECHNOLOGY AND OTHER NEW DEVELOPMENTS IN CHIMERA GRID TOOLS 2.0

William M. Chan

NASA Ames Research Center

8th Symposium on Overset Composite Grids and Solution Technology, Houston, Texas, October 2-5, 2006

OVERVIEW

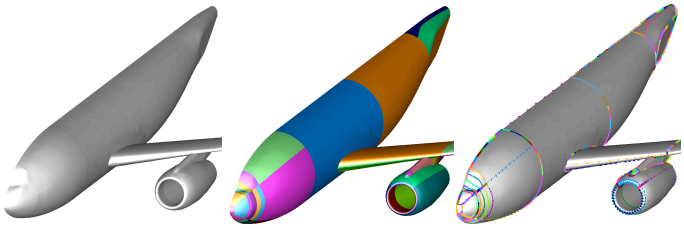
Chimera Grid Tools (CGT) is a collection of software tools for performing grid generation, flow solver input preparation, and solution analysis using overset grid methods

Version 2.0 Highlights

- CAD Interface Using CAPRI Library
- Strand Grid Technology
- OVERGRID Main Development
- CGT Main Development

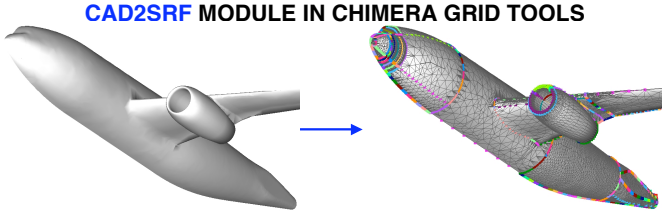
CAPRI OVERVIEW

- Single interface to native solid model CAD parts from different vendors
- Solid model concept: volumes, faces, edges, points
- Generic functions to interface with solid model
- Easy to implement into existing grid generators and GUI
- Require native CAD license and CAPRI license to run (http://www.cadnexus.com)



Volume Faces Edges

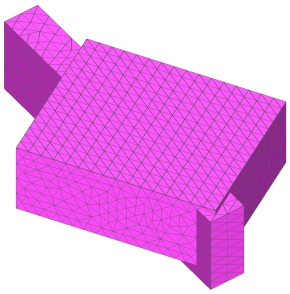
CAD2SRF MODULE IN CHIMERA GRID TOOLS



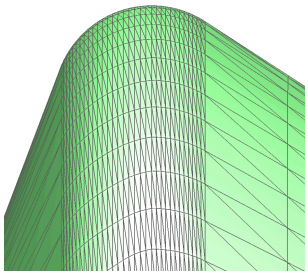
- Generate a surface triangulation from native solid CAD part
- Triangulation (based on surfTriCapri tool by M. Aftosmis)
  - representation of geometry
  - typically does not have appropriate grid point distribution for volume grid generation or flow resolution
  - contains CAD volume and face tags for each triangle (extended CART3D format)
- Write PLOT3D format files containing
  - all CAD edges
  - sorted CAD edges on symmetry plane

GRID POINT DISTRIBUTION ON CAD2SRF TRIANGULATION

Appropriate for geometry description and flow solvers based on cut-cells at the surface but not appropriate as a computational grid

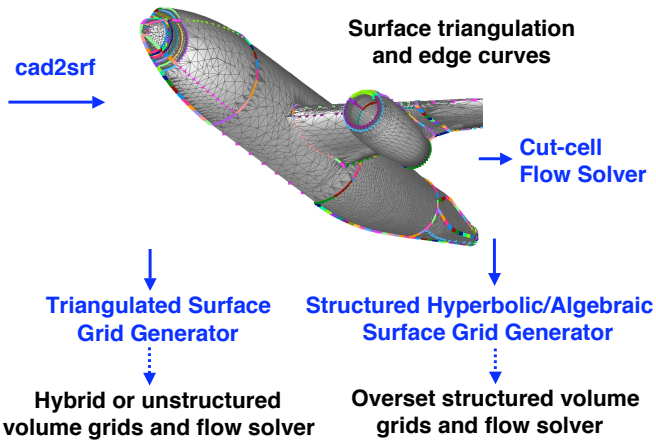


Grid points not clustered at convex corners

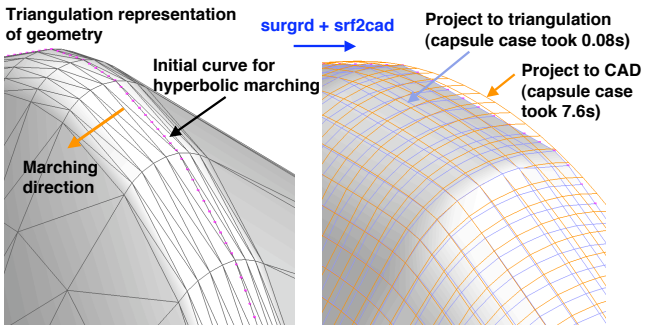


Clustering control is available at high curvature regions, but grid point distribution may not be smooth

FROM SURFACE TRIANGULATION TO GRIDS

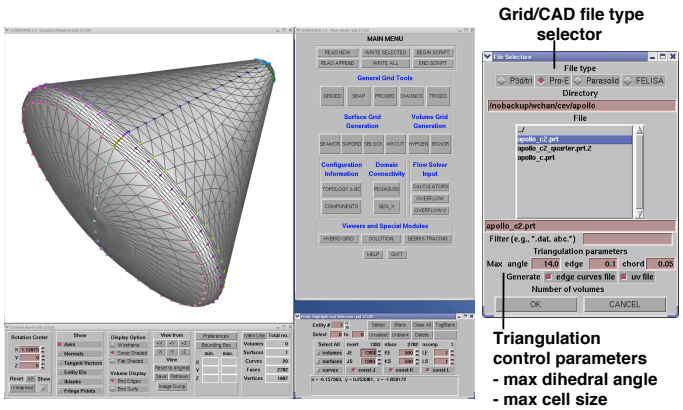


SRF2CAD MODULE IN CHIMERA GRID TOOLS

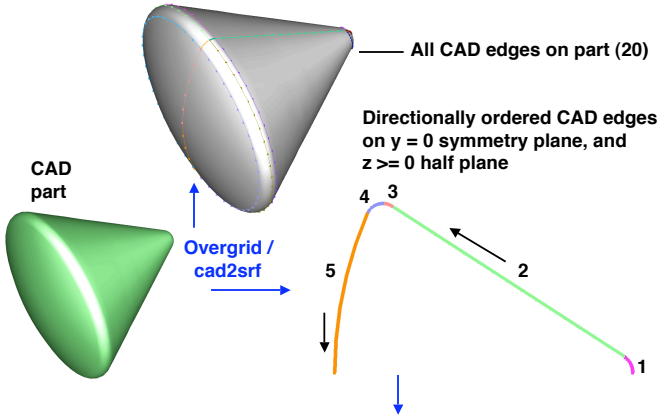


- First generate structured grid onto triangulation (surgrd)
- Triangulation stencil contains CAD volume tags and face tags
- surgrd calls srf2cad with CAD volume and face tags at each grid point
- srf2cad projects all grid points onto CAD model using inverse evaluation function from CAPRI
- Can be used for grid generation and adaptation

OVERGRID INTERFACE FOR cad2srf



FROM CAD MODEL TO GRIDS FOR AXISYMMETRIC BODIES

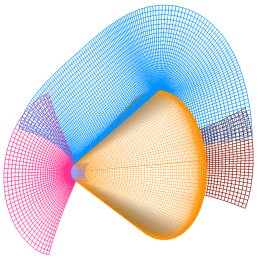


To grid generation procedures in script

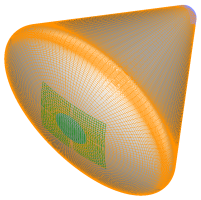
GRID GENERATION SCRIPT FOR AXISYMMETRIC BODIES

Distribute grid points on symmetry curve segments and concatenate

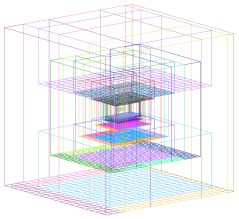
Generate near-body volume grids



Revolve to get baseline surface grid and introduce end caps



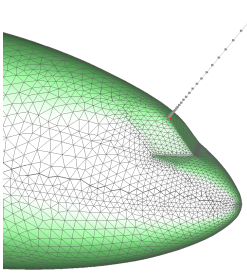
Generate off-body volume grids



STRAND GRID INTRODUCTION

- A special case of prismatic volume grid with straight lines (strands) in the body-normal direction
- Each strand defined by a direction vector and a grid point distribution function
- All strands share same length and grid point distribution
- Each strand may be clipped at a cut-off index from negative volume trimming and hole cuts
- Viscous spacing at wall stretched to larger spacing at outer boundary

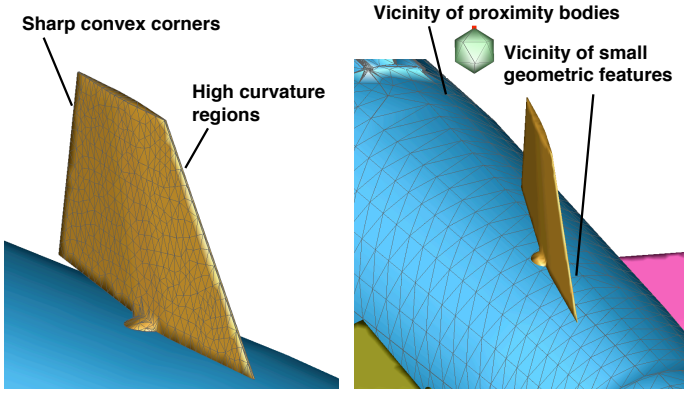
Total storage requirement =
No. of surface vertices x (6 reals + 1 int)
- surface vertex coordinates (3 reals)
- direction vector (3 reals)
- iblank cut-off from strand clipping (1 int)



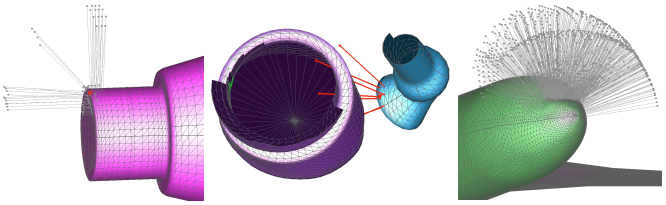
- Near-body viscous flow resolved by strand grid
- Off-body space covered by AMR Cartesian grids

SURFACE TRIANGULATION GRID POINT CLUSTERING REQUIREMENTS FOR STRAND GRID

The quality of the strand grid is highly dependent on the quality of the given initial surface triangulation



STRAND GRID DEVELOPMENT TASKS

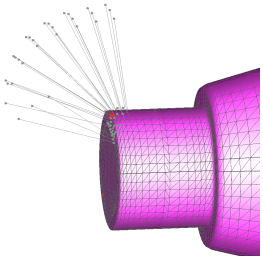


Develop methods to provide better volume coverage

Clip strands that
- are adjacent to negative volume prisms
- protude inside solid boundaries

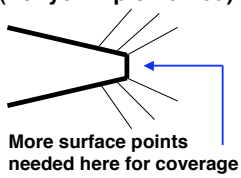
Develop visualization tool for strand grid and off-body Cartesian grids

BETTER VOLUME COVERAGE BY STRAND VECTOR ADJUSTMENTS



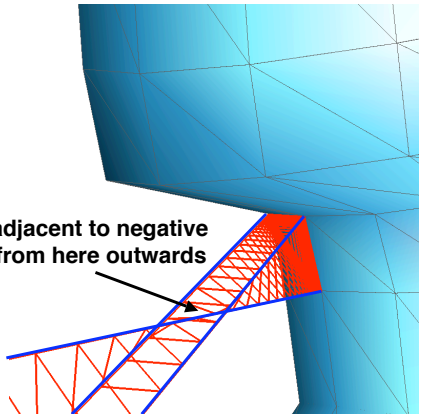
- Direction vector initially given by local surface normal
- Adjust/smooth to
  - bend towards convex corner regions for volume coverage
  - remove small negative cell volumes
  - smooth out cell volumes at interface to off-body Cartesian grids (not yet implemented)

- Direction vector adjustment alone is insufficient to fix volume coverage problems
- Also need appropriate surface grid point clustering



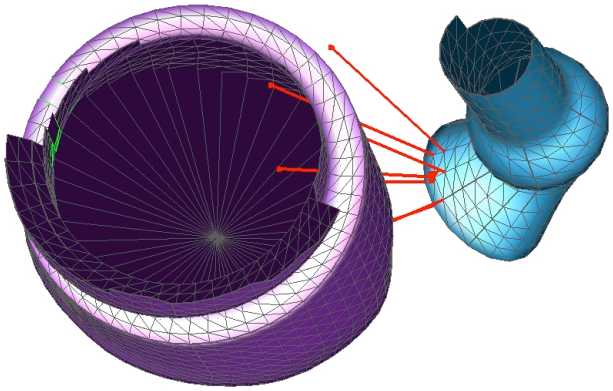
STRAND CLIPPING DUE TO NEGATIVE VOLUMES

Crossing of strands can result in negative prism cell volumes



STRAND PROTRUSION INSIDE SOLID BOUNDARIES

Task: For each strand, find intersection(s) with all triangles (from same body, or neighboring bodies)



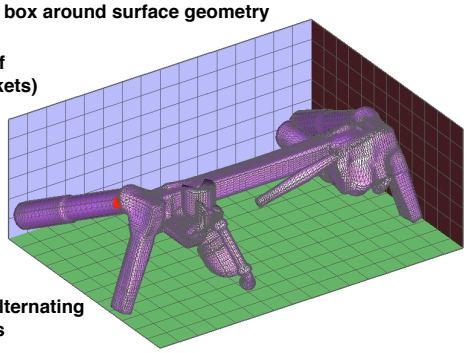
STRUCTURED AUXILIARY MESH (SAM) SEARCH ALGORITHM FOR STRAND CLIPPIING

Determine bounding box around surface geometry

Determine number of Cartesian cells (buckets) in each direction

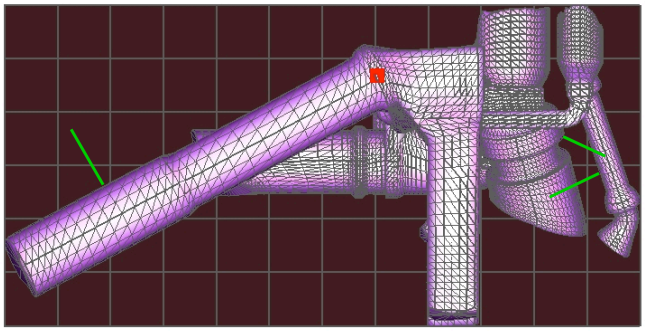
For each bucket, build list of triangles that fall inside or intersect cell

Can be faster than Alternating Digital Tree searches



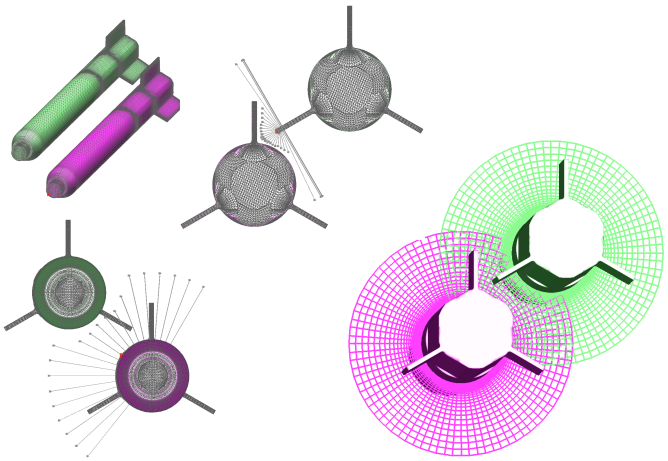
Khoshniat, Stuhne, Steinman, `Relative Performance of Geometric Search Algorithms For Interpolating Unstructured Mesh Data', Medical Image Computing and Computer-Assisted Intervention - MICCAI 2003, Springer-Verlag GmbH, Eds. Ellis and Peters.

LINE SEGMENT - TRIANGLE INTERSECTION SEARCH USING SAM ALGORITHM



Number of line segment tests = Number of surface verts
Line-box intersection --> line-triangle intersection -->
Trim line segment from first grid point below intersection point to outer boundary --> minimum hole cut

STRAND CLIPPING BETWEEN COMPONENTS



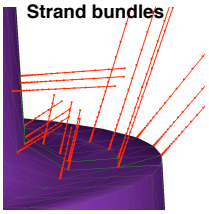
STRAND GRID GENERATION AND SAM SEARCH PERFORMANCE

Single processor AMD Opteron 244, 1.8 GHz, 1Mb cache

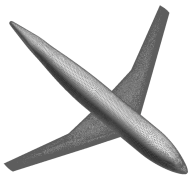
Configuration	SAM dimensions	Build time CPUsec	Search time CPUsec	Tot. grid gen.time CPUsec	No. of surface verts
2 Struts	4x3x3	8.5e-3	66.3e-3	243.e-3	1320
SSLV Attach.	8x11x4	0.355	2.58	4.47	15240
1 Dart	16x4x4	0.61	3.34	18.3	19827
2 Darts	27x6x6	2.55	9.75	42.3	39654
Wing/body	28x28x4	30	96	199	127149
Kiowa	43x11x16	191	343	669	329942

STRAND GRID VISUALIZATION USING OVERGRID

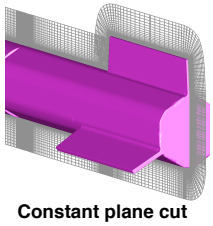
Strand bundles



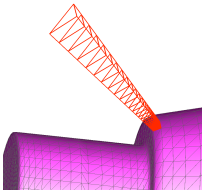
Surface shell



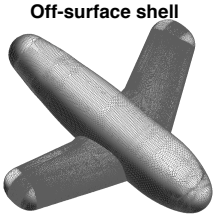
Constant plane cut



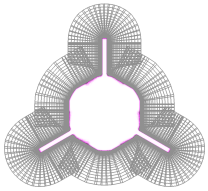
Prism stack



Off-surface shell

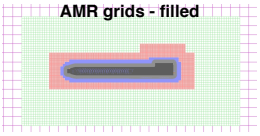


Constant plane cut

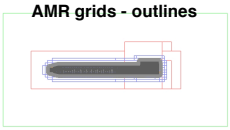


STRAND AND AMR CARTESIAN GRID CUT-PLANE VISUALIZATION USING OVERGRID

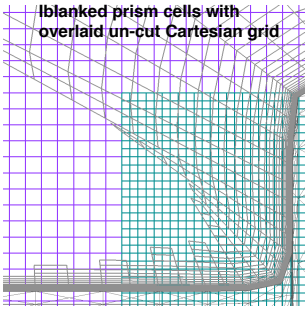
AMR grids - filled



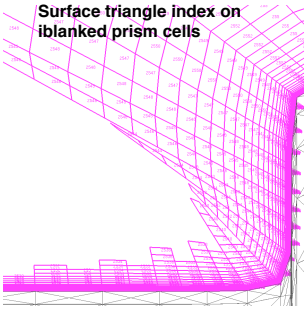
AMR grids - outlines



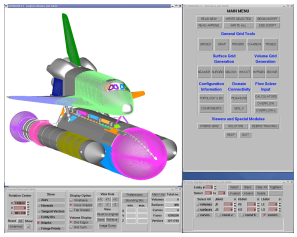
Iblanked prism cells with overlaid un-cut Cartesian grid



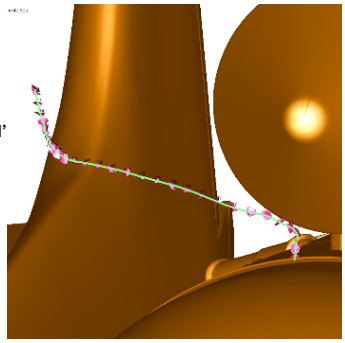
Surface triangle index on iblanked prism cells



RECENT DEVELOPMENTS IN OVERGRID GUI



Solution viewer - cut plane on Cartesian grids, log of scalars, velocity vectors
Dynamics animation - show snap shots of CG track, component orientation, force/moment vectors

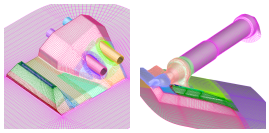


CAD interface - hook to cad2srf to `read' CAD part and display as triangulation
Triangulations - display open and bad normal edges, operate by comp. ID, separate faces by sharp edge and disjointedness criteria
Calculators - 6-dof parameters unit conversion and non-dimensionalization
Hybrid grid - strand and AMR Cartesian grids visualizer

CGT 2.0 MAIN ENHANCEMENTS, FUTURE WORK AND RECENT APPLICATIONS

CAD Interface - via CAPRI calls, cad2srf and srf2cad modules, callable from overgrid and surgrd, respectively
Strand grid - near-body grid generation module (W. Chan), used with AMR off-body Cartesian grid module (from A. Wissink, Eloret/Army)
USURP - automated force/moment computation using weighted surface quads (code by D. Boger, Penn State)
OVERPLOT/OVERHIST - compatibility with new FOMOCO history file format from OVERFLOW 2.0z+ (pressure/viscous moment breakdown)
SCRIPTLIB - cap over singular axis, create analytic curve, create cylinder grids, create hyperbolic surface grids, create X-ray hole cut, create full-body grid system from half-body system
Version 2.0 - anticipated release date: late fall 2006
Future work - CAD to abut. structured patches (quilts by J. Dannenhoffer)

Space Shuttle Attach Hardware



Apollo Abort Simulation

Crew Launch/ Exploration Vehicles